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DOI: https://doi.org/10.1016/j.obhdp.2021.04.003

Organizational Behavior and Human Decision Processes 165 (2021) 45–55

Contents lists available at ScienceDirect

Organizational Behavior and Human Decision Processes

journal homepage: www.elsevier.com/locate/obhdp

The effect of paper outcomes versus realized outcomes on subsequent risk-taking: Field evidence from casino gambling☆

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ARTICLE INFO

Keywords:
Decision making
Realization effect
Risk-taking
Prior outcome
Loss
Gain
Field analysis

ABSTRACT

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1. Introduction

How does a prior loss or a prior gain affect subsequent risk-taking behavior? People code and evaluate prior outcomes differently depending on how they engage in mental accounting activities (Thaler, 1985). Within the same mental account, prior outcomes are integrated and evaluated jointly with potential subsequent outcomes, whereas across different mental accounts, prior outcomes are segregated and thus coded separately from potential subsequent outcomes (Thaler, 1999). Consequently, as long as people consider losses to be *paper losses* that are not final because there still exists a possibility of recouping these losses, prior losses are evaluated within the same mental account (Shefrin & Statman, 1985). In contrast, if losses are considered to be *realized losses*, the mental account is closed (Barberis & Xiong, 2009, 2012; Ingersoll & Jin, 2013). Similarly, *paper gains* serve as a cushion against potential subsequent losses that are evaluated as a reduction in gains within the same mental account, whereas *realized gains* close the mental account and are evaluated separately (Merkle et al., 2020).

Imas (2016) formalizes the difference between prior paper losses and prior realized losses with respect to subsequent risk-taking in positively skewed lotteries, which he refers to as the realization effect. According to Imas (2016), a loss is realized when "money or another medium of value is transferred between accounts" (p. 2087). Based on cumulative prospect theory proposed by Tversky and Kahneman (1992), Imas (2016) predicts that individuals are likely to chase prior paper losses and thus increase their subsequent risk-taking if a successful gamble or investment can erase prior losses. In contrast, after realizing a loss, decision makers internalize the loss and close their mental account. When a decision maker closes a specific mental account, he or she also updates the reference point because subsequent prospects are evaluated relative to a new mental account (Arkes et al., 2008). In turn, once the reference point is updated, decision makers no longer feel the urge to accept higher risks to avoid a loss. Consequently, the model of Imas (2016) predicts that the level of risk-taking decreases after a prior realized loss if the sensitization of the decision maker leads to a larger distaste for losses. From these predictions, it directly follows that risk-taking is greater after a paper loss than after a realized loss (Imas, 2016).

Inspired by the work of Imas (2016), Merkle et al. (2020) extend the theoretical predictions for risk-taking behavior after gains. Building upon the model by Barberis, Huang, and Santos (2001), Merkle, Müller-Dethard, and Weber (2020) predict that prior paper gains increase risk-taking because potential subsequent losses up to the level of prior gains are not subject to loss aversion. This prediction is consistent with the "house money effect" first referred to by Thaler and Johnson (1990). Conversely, after a realized gain, the model of Merkle et al. (2020) predicts that risk-taking is the same as risk-taking before any prior outcome because the decision situation is identical.

Although numerous studies provide indirect evidence of the

☆ The authors received no financial support for the research, authorship, and/or publication of this article.

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https://doi.org/10.1016/j.obhdp.2021.04.003
Received 10 February 2020; Received in revised form 19 March 2021; Accepted 15 April 2021

realization effect (see e.g., Ackert et al., 2006; Cárdenas et al., 2014; Langer & Weber, 2008; Shiv et al., 2005), this evidence is not causal because several other differences may have led to the contrasting results (Imas, 2016). However, direct empirical evidence of the realization effect is scarce (see e.g., Imas, 2016; Merkle et al., 2020; Meyer & Pagel, 2019), and field validation of the theoretical predictions for both gains and losses in a setting with positively skewed lotteries is missing.

In this paper, we test the realization effect using data from a real-life casino. We observe the risk-taking behavior of individual gamblers within and across several visits. In addition to being a natural environment where customers make recurring decisions under risk, the casino setting allows us to differentiate between paper outcomes and realized outcomes. During a casino visit, a gambler's chance to offset prior losses remains effective and prior gains remain "house money" until he or she leaves the casino. Importantly, all gamblers use a personalized playing card while gambling in this casino. Thus, no cashing out occurs during their visit, and outcomes presumably remain paper losses or gains. However, as soon as a casino customer leaves the casino, a money transfer takes place and all prior outcomes are realized. Even Imas (2016) refers to the casino example of "cashing out and parting with the money after a loss" (p. 2087) when he illustrates the realization of losses. Consequently, it seems likely that prior outcomes within a casino are treated as paper outcomes, whereas prior outcomes between casino visits are realized.

In addition to the clean separation of paper and realized prior outcomes in a positively skewed gambling environment, our field study offers several further advantages. First, losses occurring in the casino are indeed losses of one's own money rather than losses from an initial endowment, as in most laboratory studies. Second, losses and gains in a casino are typically larger than outcomes in laboratory experiments; thus, our research setting reflects the size of prior outcomes of real-life decisions more accurately. Finally, the considerable variation in casino customers' outcome sizes allows us to distinguish between the effects of smaller and larger prior outcomes. Most importantly, the size of a prior loss allows us to investigate the sensitization prediction of Imas (2016) that larger realized losses sensitize a decision maker more than smaller realized losses.

Our dataset contains individual-level gambling information on 4,322 slot machine players who played a total of 158,586 slot machine sessions within 24,439 visits between August 1, 2016, and November 28, 2016. For each session of a player, i.e., the gambling activity on a particular slot machine, we observe the date and the point in time within the day, which allows us to reconstruct each player's gambling behavior within and across visits. Most importantly, the data also include information on the amount wagered and the amount won or lost at a particular slot machine.

Using an individual-player fixed-effects regression model, we find that during their casino visit, casino customers significantly increase their risk-taking in the presence of prior losses and that this effect further increases with the size of a loss. Analogously, prior gains within a visit increase risk-taking, and larger gains reinforce this effect. Conversely, for prior outcomes from earlier visits that have been cashed out and thus are realized, we find that players significantly decrease their level of risk-taking if realized losses are comparatively large but that risk-taking remains unchanged for comparatively small realized losses and for realized gains.

Our study contributes to the literature in several ways. Most importantly, we test the theoretical predictions of the realization effect by Imas (2016) and Merkle et al. (2020) in the field. Using individual gambling data from a real casino allows us to distinguish between risk-taking after paper outcomes within a casino visit and risk-taking after realized outcomes across casino visits. Overall, our results provide strong empirical support for the predictions of the realization effect. Second, we find that the increase in risk-taking after both paper losses and paper gains within a particular visit is more pronounced for larger outcomes. While the theoretical prediction of the size of prior paper outcomes is implicitly contained in the model of Merkle et al. (2020), it has not yet been empirically validated. Finally, we show that risk-taking decreases only for comparatively large prior realized losses. Consequently, smaller realized losses do not seem to sensitize casino customers sufficiently to induce a change in their subsequent risk-taking behavior. This finding is consistent with the sensitization prediction of Imas (2016), although we cannot completely rule out wealth effects as an alternative explanation.

The remainder of this paper is organized as follows. In Section 2, we review the related literature. In Section 3, we describe the casino setting and derive our hypotheses. In Section 4, we describe our data and our empirical methods. In Section 5, we present our empirical results and several robustness tests. In Section 6, we discuss our results and conclude the paper.

2. Related literature

Numerous previous studies provide indirect evidence of the realization effect. Reanalyzing existing empirical evidence, Imas (2016) demonstrates that distinguishing between realized and paper losses reconciles the contradictory findings in the literature. For example, Langer and Weber (2008) and Shiv et al. (2005) both employ the experimental investment game used by Gneezy and Potters (1997).[1] While the participants in Langer and Weber (2008) experienced paper losses and took more risk after a loss, the participants in Shiv et al. (2005) experienced realized losses after each round and took less risk after a loss. Furthermore, the field studies of Coval and Shumway (2005) and Liu et al. (2010) analyze the risk-taking behavior of professional traders after morning losses. Coval and Shumway (2005) find that traders increase their risk-taking while Liu et al. (2010) find that traders decrease their risk-taking in the afternoon. The contrast in the results could be explained by differences in paper and realized losses: The traders in Coval and Shumway (2005) mostly experienced paper losses, while the traders in Liu et al. (2010) mostly experienced realized losses.

A similar pattern seems to arise from studies analyzing prior gains. For example, Ackert et al. (2006) find that individuals with larger prior gains become more risk-taking in a financial market experiment where prior gains remained unrealized. This finding is consistent with that of Hsu and Chow (2013), who investigate individual investors in the stock market and find that they tend to buy more risky stocks after gains but that this effect diminishes over time. Thus, it seems that investors update their reference point over time and gains become realized.

Gains are also realized for the treatment group in Cárdenas et al. (2014), who distributed an endowment three weeks before the experiment took place. Interestingly, the individuals in this treatment group were slightly more risk averse than those in a control group that received the same endowment just before the experiment. Finally, Rüdisser et al. (2017) investigate risk-taking after prior gains in a real casino. The authors find that individuals in the treatment group who received a free play coupon after entering the casino became more risk averse than individuals who did not receive anything. Because the free play coupons were provided in a separate transaction, these gains might have been realized, which could explain the absence of a house money effect.

To date, only a few studies offer direct empirical evidence of the realization effect. Imas (2016) adopts the investment experiment used by Gneezy and Potters (1997) that involves a sequence of four positively skewed lotteries. After the third lottery, individuals in the "paper treatment" simply continued to the fourth lottery, whereas individuals in the "realized treatment" had to transfer the amount lost to the experimenter before continuing. When comparing the investment amount in the third lottery to that in the fourth lottery of subjects who

[1] Gneezy and Potters (1997) and several other studies (e.g., Benartzi & Thaler, 1999; Keren, 1991; Klos et al., 2005) have demonstrated that risk-taking increases when gambles are played multiple times.

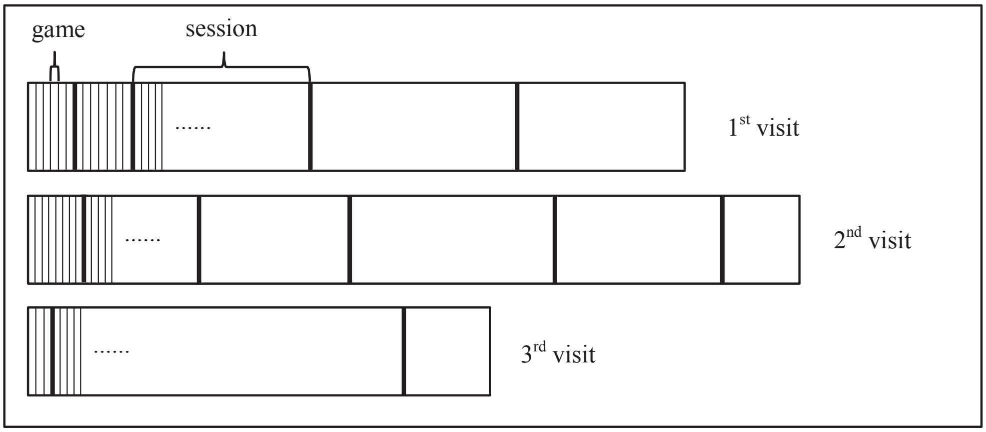

Fig. 1. Aggregation of casino data at the visit, session and game levels.

lost the first three lotteries, Imas (2016) finds that subjects in the "paper treatment" increased their investment in the fourth lottery, whereas subjects in the "realized treatment" decreased their investment. Thus, decision makers engage in less risk-taking following a loss if the loss is realized and engage in more risk-taking if the loss is a paper loss. Furthermore, Merkle et al. (2020) replicate the design by Imas (2016) using a larger sample size and test the realization effect for prior outcomes. Consistent with their theoretical predictions, Merkle et al. (2020) find a strong realization effect for gains and losses in positively skewed lotteries but no differential risk-taking in non-positively skewed lotteries. Finally, in contemporaneous work, Meyer and Pagel (2019) analyze mutual fund liquidations as exogenous realizations of capital gains and losses. The authors show that individual retail investors reinvest 83% in the presence of a net gain but only 40% in the presence of a net loss, which provides field evidence for the realization effect. Considering that the underlying distribution of outcomes in stocks or mutual funds is generally negatively skewed, the results of Meyer and Pagel (2019) are surprising because neither Nielsen (2019) nor Merkle et al. (2020) find evidence of a realization effect in non-positively skewed lotteries. Overall, direct empirical field evidence in a setting with positively skewed lotteries is non-existent, and our casino setting offers an ideal opportunity to test the theoretical predictions underlying the realization effect.

3. Casino setting and hypotheses

3.1. Casino setting

We examine casino customers' gambling decisions that are observed throughout and across their visits in a Swiss casino. Upon entering the casino, customers must show a valid identification document (e.g., passport or ID card) and receive a new personalized playing card on which they load their preferred amount of money. This playing card must be used to play at slot machines and must be shown to the croupiers who operate the table games. Casino customers can reload their card at any point in time during their visit. At the end of the visit, the final account balance, i.e., the amount of money left on the playing card, is paid out and transferred back to the casino customers. In this process, the playing card is retained by the casino cashier. Customers who have lost all of the money on their card can put the card in a box when leaving the casino or simply take the card with them and throw it away.

During their casino visit, customers may play one or more games at one particular slot machine or table. The aggregation of all games a customer plays at one slot machine or table before switching to a different game or leaving the casino is referred to as one session. In turn, a casino visit consists of one or more sessions a customer played sequentially before leaving the casino. Fig. 1 shows an illustrative example of a casino customer visiting the casino three times during a certain period. This casino customer engages in five sessions throughout his or her first visit and plays six games in his or her first session.

The individual playing card allows the casino to systematically track the gambling behavior of casino customers throughout and across their visits. However, for its internal reporting procedures, the casino only records data at the session level. While slot machines automatically record the gambling activity, the croupiers of the table games act as monitors and manually enter certain gambling data into the casino's system.

In our Swiss casino setting, there are over 300 different slot machines customers can choose from. Each slot machine offers positively skewed gambles and displays the minimal and maximal wagers per game. Within this range, casino customers can choose how much they want to wager in each spin.[2] At any given slot machine, casino customers have two choices to make. First, they can choose the number of paylines they want to bet on, and second, they can determine the wager per payline. Because the payouts are proportionate to the wager per payline and the winning probabilities are identical for any payline, a higher total wager per spin implies higher risk-taking independently of how the wager is split up between paylines. Furthermore, outcomes on slot machines are random and not influenced by any player skills (Harrigan & Dixon, 2009). While the house edge, i.e., the percentage a gambler would lose if he or she played the same game an infinite number of times, and thus the risk-return profiles of different slot machines vary, they are not directly visible to casino customers. Rather, casino operators typically have incentives to remain untransparent regarding the house edge because it essentially reflects the "price" for gambling on a certain slot machine (Lucas & Spilde, 2019b).

A casino constitutes an ideal setting in which to examine the risk-taking behavior of individuals. Indeed, other studies have used data from casino games to study risk-taking in the presence of prior outcomes (e.g., Eil & Lien, 2014; Rüdisser et al., 2017; Smith et al., 2009) or have implemented casino-style tasks in their experimental studies (e.g., Arkes et al., 1994; Cárdenas et al., 2014; Weber & Zuchel, 2005). Moreover, casino data allow us to differentiate between paper and realized outcomes. On the one hand, we can presume that a casino customer's mental account remains open and the reference point is not updated between sessions within a visit for several reasons. First, there is typically no physical transfer of the playing-card money between sessions,

[2] The only restriction is that an increase in the wager must follow in the manner of the minimum wager per game. For example, if the minimum wager per game is 1, wagers of 1, 2, 3, 4, 5, up to the maximum wager are feasible.

and the amount remains on the playing card within a visit.[3] Second, casino customers who have experienced a loss in their previous session switch to a different slot machine, and the chance to offset prior losses remains effective as long as they stay in the casino. Analogously, accumulated prior gains serve as a cushion against potential losses in further gambling sessions at different slot machines. Third, Frydman et al. (2017) suggest that a mental account is rolled into the subsequent investment period if the reinvestment closely follows the prior investment. In our setting, sessions typically directly follow one another.

On the other hand, at the end of a visit, casino customers realize their final account balance. When they go to the casino cashier, customers hand in their playing card and receive the accumulated amount of money in return; i.e., the final amount is physically transferred from the playing card to the casino customer. Consequently, after leaving the casino, a customer no longer has the chance to offset prior losses or the opportunity to gamble with "house money" in case of prior gains. Thus, we argue that casino customers realize their outcomes at the end of a visit and close their mental account accordingly.

3.2. Hypotheses

Based on the theoretical predictions developed by Imas (2016) and Merkle et al. (2020), we derive testable hypotheses for our casino setting. For risk-taking after a paper loss, both models predict that individuals increase their level of risk-taking because evaluating prior losses within the same mental account upholds the hope that a successful subsequent lottery will erase the prior loss. In our paper, we argue that prior losses within a casino visit are not regarded as final because recouping these losses is still possible. Thus, prior losses within a casino visit remain paper losses, and we hypothesize the following:

H1a: Within a visit, casino customers increase their level of risk-taking after a loss.

Merkle et al. (2020) model a mental account as the sum of prior outcomes. Consequently, individuals also care about the level of cumulative prior losses, and gambles that allow them to break even are especially attractive (Merkle et al., 2020; Suhonen & Saastamoinen, 2017; Thaler & Johnson, 1990). This implies that if prior paper losses are large, risk-taking must be even more extreme to break even. Indeed, Smith et al. (2009) find that the fraction of poker players playing more "loosely", i.e., putting money into the pot to hit a long-shot flop with a weak hand, consistently increases as the size of the prior loss increases. Similarly, casino customers who have accumulated comparatively large paper losses in their mental account might take on more subsequent risks in the hope of winning back enough money to recover their losses. This tendency is referred to as loss-chasing in the gambling literature (Zhang & Clark, 2020). Thus, we hypothesize that larger prior losses during a visit lead to more pronounced risk-taking than smaller prior losses:

H1b: Within a visit, the size of a prior loss amplifies the increase in casino customers' level of risk-taking.

Merkle et al. (2020) predict that individuals likewise increase their level of risk-taking after a paper gain. Because prior paper gains and risky prospects are jointly evaluated within the same mental account, prior gains serve as a cushion against potential losses, which are thus perceived as less painful. In the casino, prior gains are likely regarded as paper gains as long as individuals continue gambling within a visit. We hypothesize the following:

H2a: Within a visit, casino customers increase their level of risk-taking after a gain.

As implied in the model by Merkle et al. (2020), larger prior paper gains allow individuals to offset larger potential losses. When casino customers accumulate comparatively large paper gains, they are able to bet more in subsequent gambles without the risk that their mental account will show a net loss. Thus, within a casino visit, we expect more risk-taking after larger gains compared to smaller gains:

H2b: Within a visit, the size of a prior gain amplifies the increase in casino customers' level of risk-taking.

After realizing a loss, decision makers internalize this loss, close their mental account, and update their reference point (Imas, 2016). Thus, there is no longer an option to break even, and they stop chasing losses (Merkle et al., 2020). Moreover, Imas (2016) proposes that sensitization to further losses (Barberis et al., 2001; Thaler & Johnson, 1990) translates into a larger distaste for losses.[4] Thus, decision makers become more loss averse after a prior realized loss and are less willing to take on risks. Consequently, the level of risk-taking is expected to be lower after a realized loss than before a realized loss.[5] In our setting, losses are realized as soon as customers decide to leave the casino. Thus, we expect that realized losses from earlier visits reduce casino customers' level of risk-taking:

H3a: Between visits, casino customers reduce their level of risk-taking after a loss.

Regarding the size of realized losses, the incorporation of sensitization in Imas (2016) framework allows loss aversion to depend on the sum of prior realized losses. Consequently, a larger realized loss sensitizes decision makers more than a smaller realized loss, and we hypothesize that larger prior losses from earlier visits lead to a more pronounced reduction in risk-taking:

H3b: Between visits, the size of a prior loss amplifies the decrease in casino customers' level of risk-taking.

Finally, realizing a gain also closes the mental account and resets the reference point. However, because sensitization seems less relevant for the gain domain, we follow Merkle et al. (2020), who predict that the level of risk-taking after a realized gain is similar to that in a decision without prior outcomes. Thus, we hypothesize the following:

H4: Between visits, casino customers do not alter their level of risk-taking after a gain.

In the following, we will empirically test these hypotheses to validate the realization effect after both losses and gains using individual-level gambling data.

4. Data and methods

4.1. Data

Our data, provided by a Swiss casino, contain individual-level

[3] Even though the possibility exists, it seems unlikely that casino customers systematically cash out the money on their playing card and afterwards, instead of leaving the casino, reload the card to restart gambling. Such behavior would only result in additional transaction costs in the form of lost gambling time.

[4] In addition to sensitization, Imas (2016) refers to several further mechanisms, such as the increased salience of the potential downside of risk (Bordalo et al., 2012), a change in mood (Loewenstein, 1996) or a diminished capacity for dealing with negative events (e.g., Pagel, 2017), that also produce a greater distaste for losses after a realized loss.

[5] The model of Merkle et al. (2020) predicts that individuals' risk-taking behavior is not affected after realized losses because it assumes a constant loss aversion parameter without sensitization, while Imas (2016) argues that realized losses lead to an increase in loss aversion parameter λ and thus lower subsequent risk-taking. Because the predictions by Imas (2016) and Merkle et al. (2020) are mutually exclusive, we rely solely on Imas (2016) to develop Hypotheses 3a and 3b.

Table 1
Descriptive statistics.

Variable	Mean	Median	Std. dev.
TotalWager	649.99	152.00	3,722.08
Number of minutes	20.00	8.13	39.01
Number of games	257.38	100.00	544.36
Amount won	−31.28	−30.00	561.70
T-winCasino	30.14	8.18	120.75

Notes: The table reports the descriptive statistics. All observations are at the session level (N = 158,586). The total number of players is 4,322, and the total number of visits is 24,439. All values are in CHF.

gambling information on slot machine players[6] at the session level over the period from August 1, 2016, to November 28, 2016.[7] We have information on the date of all casino customers' visits and the chronology of the sessions within a visit. Most importantly, the dataset includes detailed information on casino customers' gambling decisions. This information includes the total amount wagered, the number of games played, the amount of time spent playing, and the corresponding gambling outcomes, i.e., the total amount lost and won, on a specific slot machine. Additionally, we observe the theoretical wins for the casino. This measure is calculated as a slot's specific house edge multiplied by the total amount wagered. For example, if a casino customer wagered one dollar on a slot machine with a 5% house edge, the theoretical win for the casino is 0.05, irrespective of the actual outcome of the gamble (Lucas & Spilde, 2019a).

Overall, the dataset contains 4,322 individual casino customers who played a total of 158,586 sessions within 24,439 visits. Thus, an average casino visit consists of approximately 6.5 sessions. Table 1 shows the descriptive statistics. On average, a casino customer spends approximately 20 min on a slot machine, gambles 257 games, wagers 650 Swiss francs (CHF), and loses CHF 31.[8] Based on the amount wagered and the house edge, the theoretical amount won by the casino (*T-winCasino*) is approximately CHF 30 per session.

Our data show that typical losses and gains in an individual's casino visit are moderate. The median final balance at the end of a casino customer's visit is CHF −100. Relative to the median monthly income in Switzerland, this is a small amount, approximately 1.5%.[9] Moreover, the average number of visits per customer within our sample period of four months is approximately 5.7. Thus, a casino customer visits the casino once every three weeks on average.

4.2. Risk variables

In our main analysis, we employ two variables to measure risk-taking. First, we use *TotalWager,* which is the total amount wagered within a session. For a given slot machine, a higher total wager increases both the potential win and the potential loss. Thus, the total wager measures casino customers' level of risk-taking. A similar approach has been used in several other studies on individuals' risk-taking behavior (e.g., Flepp & Rüdisser, 2019; Haigh & List, 2005; McGlothin, 1956; Rüdisser et al., 2017; Suhonen & Saastamoinen, 2017).

Second, we employ the theoretical win for the casino (*T-winCasino*) as an additional measure of risk-taking. The risk profile of the slot machine is proxied by the house edge because slot machines with a low house edge tend to have a lower volatility in payoffs than slot machines with a large house edge. Simply stated, the higher house edge for volatile games is necessary to offset the greater financial risk for the casino when it offers large winnings (Turner & Horbay, 2004). However, the house edge picks up only one aspect of the risk taken because the amount wagered is potentially endogenous to the risk profile. Casino customers gambling on a highly volatile slot may wager less than they would when gambling on a low-volatility slot, which makes an interpretation of their overall risk-taking difficult. Thus, as a combined measure of the total amount wagered and the house edge, *T-winCasino* reflects the overall risk a casino customer takes within a session.

4.3. Prior outcome variables

We measure prior outcomes both within a visit and between visits based on the sum of prior outcomes. Within-visit prior outcomes reflect prior paper outcomes and are set to zero at the beginning of each visit because no prior paper outcomes are present. This operationalization closely follows the model of Merkle et al. (2020). Between-visit prior outcomes reflect realized outcomes and are calculated as the sum of prior outcomes from all previous visits in our dataset. This approach is similar to the framework in the online Appendix of Imas (2016), where loss aversion depends on the sum of prior realized outcomes.[10]

Because prior gains and losses are evaluated against the reference point, it is of critical importance to define the reference point appropriately. Naturally, the reference point in most settings is assumed to be the initial level of wealth. However, previous research also shows that expectations serve as reference points (see, e.g., Abeler et al., 2011; Bartling et al., 2015; Koszegi & Rabin, 2006). Thus, because casino customers may expect to lose some money during their stay in the casino, the reference point remains ambiguous. To address this issue, we construct dummy variables based on the five quintiles Q_z from the distribution of prior outcomes within a visit (*PaperOutcome*Q_z) and dummy variables based on the five quintiles from the distribution of prior outcomes across visits (*RealizedOutcome*Q_z), where z refers to the respective quintile number. This allows us to compare the relative effect of each prior outcome quintile on risk-taking.[11] For ease of interpretation, we define the quintile that contains the net prior paper outcome of zero and the quintile that contains the net prior realized outcome of zero as the reference categories.

4.4. Estimation equation

To test our hypotheses presented in Section 3.2, we use an individual-player fixed-effects ordinary least squares model. Our main estimation equation can be written as follows:

$$Y_{is} = \alpha_i + \beta PaperOutcomeQ_{z\_is} + \beta RealizedOutcomeQ_{z\_is} + X_{is}^{'}\beta + \varepsilon_{is}, \quad (1)$$

[6] Because croupiers record gambling data in less detail and accuracy than slot machines do, the casino provided us with individual gambling records of slot machine players. Throughout all their visits, these casino customers gambled only on slot machines.

[7] The original dataset provided by the casino contained two additional days (November 29 and November 30, 2016). Due to an obvious data coding error (in all sessions of all customers, the amount won was always equal to the total wager), we deleted these observations.

[8] The currency used in Switzerland is the Swiss franc (CHF). During the examination period, the CHF and the U.S. Dollar (USD) were approximately at par value.

[9] For detailed information on the monthly salaries in Switzerland, see the results published by the Swiss Federal Statistical Office (https://www.bfs.admin.ch/bfs/en/home/statistics/work-income/wages-income-employment-labour-costs.html).

[10] Because we assume that only paper outcomes change within a visit and realized prior outcomes are not affected by within-visit outcomes, realized prior outcomes are identical for each session within a particular visit.

[11] Furthermore, this approach resolves a technical limitation in our setting. Because most casino customers only have prior paper outcomes of exactly zero at the beginning of their first session, it is challenging to separate the risk-taking effect without prior outcomes from other systematic differences that might exist between the first and subsequent sessions. For example, there might be something unique about the first session because casino customers may want to quickly sample slot machines at the beginning of their visit. The same difficulty occurs for realized outcomes and systematic differences between the first and subsequent visits.

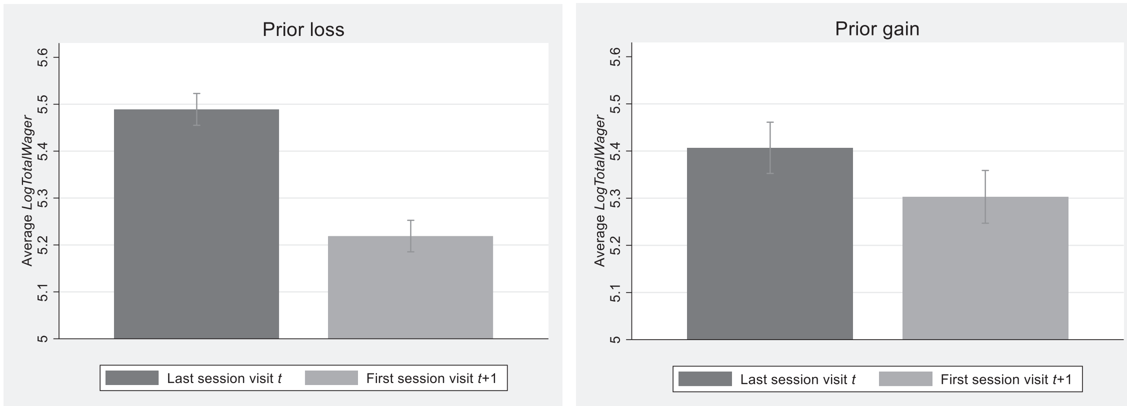

Fig. 2. Average *LogTotalWager* in the last session visit t and in the first session visits $t+1$. Notes: The left panel shows the average *LogTotalWager* for the last session in visit t and for the first session in visit $t+1$ in the presence of a prior loss. The right panel shows the respective averages in the presence of a prior gain. The first session of visit 1 and the last session of the final visit in the dataset are not included. The error bars show the 95% confidence intervals of the averages.

where i indicates the casino customer and s indicates the session. For the dependent variable Y_{is}, we employ the casino customer's total wager on a logarithmic scale (*LogTotalWager*) and the theoretical win for the casino on a logarithmic scale (*LogT-winCasino*).[12] *PaperOutcomeQ*$_z$ represents indicator variables for the quintiles of prior outcomes within a visit, and *RealizedOutcomeQ*$_z$ represents indicator variables for the quintiles of prior outcomes across visits. The baseline quintiles that include the net prior paper or realized outcome of zero are omitted and serve as reference points against which the remaining quintiles will be compared.

X contains a set of control variables. In particular, to account for the differences between slot machines in terms of risk profiles and payout schemes, we include slot machine dummies.[13] We further include session-number dummies and a continuous variable for the visit number to account for differences across sessions and visits.[14] Additionally, we include a dummy variable for each calendar day to account for differences between casino customers' visits and for differences between the point in time of casino visits, e.g., weekdays versus weekends or the beginning versus the end of the month. Finally, our model includes individual-player fixed effects to control for unobserved but time-constant differences in casino customers' risk-taking behavior. All of our estimations use heteroscedasticity-robust standard errors.

5. Results

5.1. Descriptive evidence

We begin by presenting descriptive evidence showing that casino customers take more risk at the end of a given visit than at the beginning of the next visit. Fig. 2 shows the average *LogTotalWager* of the same casino customer in the last session of visit t and in the first session of visit $t+1$ for prior losses (left graph) and prior gains (right graph). After a loss within a visit, the average *LogTotalWager* in the last session is 5.49 but drops to 5.22 in the first session of the next visit. A paired, two-sided t-test reveals that this difference is statistically significant ($t(8,949) = 14.44$, $p < 0.001$) and implies that casino customers take more risk after within-visit losses than after between-visit losses. Similarly, casino customers wager significantly more in the last session of visit t than in the first session of the next visit ($t(3,233) = 3.40$, $p < 0.001$) in the presence of prior gains.[15]

We interpret these results as first suggestive evidence of a realization effect for both prior losses and prior gains. We note, however, that the results in Fig. 2 do not control for confounding effects such as systematic

Table 2
Main results.

	LogTotalWager (1)	*LogT-winCasino* (2)
Prior outcomes within the visit		
PaperOutcomeQ$_{1[\leq -310]}$	0.0968***	0.0959***
	(0.0183)	(0.0187)
PaperOutcomeQ$_{2[-309, -97]}$	0.0518***	0.0519***
	(0.0127)	(0.0139)
PaperOutcomeQ$_{3[-96, 0]}$	Baseline	Baseline
PaperOutcomeQ$_{4[1, 80]}$	0.0374**	0.0333**
	(0.0153)	(0.0156)
PaperOutcomeQ$_{5[\geq 81]}$	0.0929***	0.0957***
	(0.0165)	(0.0166)
Prior outcomes between visits		
RealizedOutcomeQ$_{1[\leq -2,791]}$	−0.1018***	−0.1012***
	(0.0308)	(0.0321)
RealizedOutcomeQ$_{2[-2,790, -788]}$	−0.0496**	−0.0493*
	(0.0249)	(0.0257)
RealizedOutcomeQ$_{3[-787, -63]}$	−0.0099	−0.0114
	(0.0197)	(0.0199)
RealizedOutcomeQ$_{4[-62, 0]}$	Baseline	Baseline
RealizedOutcomeQ$_{5[\geq 1]}$	0.0177	0.0236
	(0.0206)	(0.0209)
VisitNumber	0.0011	0.0008
	(0.0013)	(0.0013)
Slot machine dummies	X	
Session dummies	X	X
Date dummies	X	X
Player fixed effects	X	X
Observations	158,586	158,586
Within R^2	0.047	0.005

Notes: The heteroscedasticity-robust standard errors are given in parentheses. The number of casino customers is 4,322. In all models, *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

[12] We employ a logarithmic value in all of our models because of the skewed distribution of the size of the wagers. Earlier studies have used a similar approach (e.g., Flepp & Rüdisser, 2019; Suhonen & Saastamoinen, 2017).

[13] For the estimations using *LogT-winCasino*, the slot machine dummies are omitted because *LogT-winCasino* already incorporates the house edge of the slot machine.

[14] We include a continuous variable for the visit number instead of visit-number dummies because our dataset starts at an arbitrary point in time and we observe only the number of visits within our data period instead of the actual number of visits of the casino customers. Thus, estimating a linear effect of the visit number is more meaningful than including visit-number dummies.

[15] The results for *LogT-winCasino* as a risk measure are similar, and the differences for both prior losses and prior gains are significant at the 1% level.

differences in risk-taking between sessions or visits. In the subsequent analyses, we carefully control for alternative explanations that may result in a similar empirical pattern and test our hypotheses in more detail.

5.2. Main results

Table 2 shows our main estimation results for Equation (1). The estimates in Column (1) show that prior losses and prior gains within a visit increase the *LogTotalWager* relative to the baseline and that this increase is more pronounced for larger outcomes. Specifically, relative to the baseline wager for prior paper outcomes in Q_3 between −96 and 0, prior losses between −97 and −309 in Q_2 are associated with an increase in the *LogTotalWager* of approximately 5.2%, while prior paper losses larger than −309 in Q_1 increase the amount wagered by approximately 9.7% on average. This difference in the estimated coefficients is statistically significant ($p < 0.001$). Laterally reversed, prior within-visit gains between 1 and 80 in Q_4 increase the amount wagered by approximately 3.7%, whereas gains larger than 80 increase the amount wagered by approximately 9.3% relative to the baseline wager. Again, the difference between the two coefficients is statistically significant. Combined, these findings are consistent with our hypotheses that both prior paper losses and paper gains within visits increase the level of risk-taking (H1a and H2a) and that this impact is more pronounced for larger prior outcomes (H1b and H2b).

Column (1) of Table 2 further shows the estimates for prior realized outcomes between visits relative to reference quintile Q_4, which contains prior realized outcomes from −62 to 0. Compared to this baseline, prior losses between −63 and −787 do not significantly alter the *LogTotalWager*. However, larger prior losses in quintiles Q_2 and Q_1 reduce the *LogTotalWager* significantly, by approximately 5.0% and 10.2%, respectively. Thus, we find no general support for H3a that risk-taking is reduced after realized losses from previous visits. However, our results provide supportive evidence for H3b that larger realized losses decrease the level of risk-taking more than smaller realized losses. Conversely, prior gains from previous visits (Q_5) have no significant effect on the *LogTotalWager*, which is in line with H4 that realized gains do not significantly alter risk-taking behavior.

Column (2) of Table 2 shows the results for *LogT-winCasino* as a risk measure. Overall, the findings are very similar to those in Column (1). The similarity of the estimated coefficients implies that prior outcomes have little effect on the choice of slot machines with certain risk profiles. One explanation for this finding is that the risk profiles of slot machines are not ex ante visible to the casino customer, which makes the choice of specific slot machines arbitrary. Moreover, recent empirical evidence from casinos suggests that casino customers have great difficulty detecting the house edge (and thus the volatility) of a slot machine even after many spins (Lucas & Spilde, 2019a, 2019b; Turner, 2011). Furthermore, Harrigan and Dixon (2009) highlight that multiple versions of the same slot machine game with different risk profiles are common, which further complicates learning about the risk profiles.

Overall, our results provide evidence that consistent with the realization effect, risk-taking greatly depends on whether prior outcomes have been realized or remain on paper. Within a visit, prior losses and gains significantly increase risk-taking. Consistent with the predictions by Imas (2016) and Merkle et al. (2020), we further find that larger prior outcomes increase risk-taking even more. By contrast, risk-taking across visits tends to be lower for prior losses, but only relatively large prior losses of approximately CHF 800 or above decrease risk-taking significantly. Finally, we show that prior realized gains have no effect on the risk-taking behavior of casino customers, which is consistent with the explanation that the decision situation is identical to the decision situation before any prior outcome.

Table 3
Robustness results for a subsample of non-regular casino customers.

	LogTotalWager (1)	*LogT-winCasino* (2)
Prior outcomes within the visit		
PaperOutcomeQ$_{1[\leq -302]}$	0.1041***	0.0997***
	(0.0248)	(0.0250)
PaperOutcomeQ$_{2[-301, -91]}$	0.0512***	0.0540***
	(0.0166)	(0.0167)
PaperOutcomeQ$_{3[-90, 0]}$	Baseline	Baseline
PaperOutcomeQ$_{4[1, 96]}$	0.0399*	0.0339*
	(0.0204)	(0.0205)
PaperOutcomeQ$_{5[\geq 97]}$	0.0694***	0.0711***
	(0.0211)	(0.0212)
Prior outcomes between visits		
RealizedOutcomeQ$_{1[\leq -2,657]}$	−0.0717*	−0.0693
	(0.0432)	(0.0450)
RealizedOutcomeQ$_{2[-2,656, -669]}$	−0.0590	−0.0518
	(0.0367)	(0.0378)
RealizedOutcomeQ$_{3[-668, -29]}$	0.0004	0.0075
	(0.0292)	(0.0301)
RealizedOutcomeQ$_{4[-28, 0]}$	Baseline	Baseline
RealizedOutcomeQ$_{5[\geq 1]}$	0.0292	0.0329
	(0.0323)	(0.0332)
VisitNumber	0.0006	0.0004
	(0.0022)	(0.0022)
Slot machine dummies	X	
Session dummies	X	X
Date dummies	X	X
Player fixed effects	X	X
Observations	73,812	73,812
Within R^2	0.057	0.006

Notes: The heteroscedasticity-robust standard errors are given in parentheses. The subsample consists of 2,231 casino customers who did not visit the casino between October 1, 2015 and April 17, 2016, before our observation period. In all models, *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

5.3. Robustness

In the following, we present several robustness checks and address a number of concerns. We begin by showing that our results do not depend on the choice of the number of quantiles from the prior outcome distribution. In turn, we address the concern that realized outcomes prior to the first visit in our dataset remain unobserved. Finally, we investigate several other choices of casino customers that can be interpreted as additional proxies for risk-taking.

5.3.1. Alternative quantile specification

To check the robustness of our main results, we portion the prior outcomes within and across visits into 10 quantiles instead of 5 quintiles. The results are displayed in Table A1 in the Appendix. The reference quantile for paper losses narrows to −37 to 0, which is closer to a traditional interpretation of no prior outcomes. Column (1) of Table A1 shows that compared to this baseline, even small prior losses between −38 and −96 significantly increase the *LogTotalWager* by approximately 3.5%. As before, larger prior paper losses lead to a further increase in the *LogTotalWager* up to an estimated effect of 15.0% for the largest prior paper losses above CHF 597. Similarly, having a small paper gain between 1 and 80 already increases the *LogTotalWager* by approximately 5.9% compared to the baseline. The largest prior paper gains above CHF 365 increase the *LogTotalWager* by approximately 18.5% and thus have the most pronounced impact on risk-taking. For realized outcomes, the pattern in Column (1) in Table A1 is also very similar to the pattern of our main results. While realized losses above approximately CHF 800 significantly reduce the *LogTotalWager* in the subsequent visit, there is

Table 4
Prior outcomes and the probability of playing another session, the probability of visiting the casino again and the number of days between visits.

	Play another session (0/1) (1)	*Visit the casino again (0/1)* (2)	*Days between visits* (3)
Prior outcomes within the visit			
PaperOutcomeQ$_{1[\leq -393]}$	−0.0614***		
	(0.0044)		
PaperOutcomeQ$_{2[-392, -148]}$	−0.0284***		
	(0.0034)		
PaperOutcomeQ$_{3[-147, -36]}$	−0.0222***		
	(0.0034)		
PaperOutcomeQ$_{4[-35, 127]}$	Baseline		
PaperOutcomeQ$_{5[\geq 128]}$	0.0072**		
	(0.0033)		
Prior outcomes between visits			
RealizedOutcomeQ$_{1[\leq -2,791]}$ / $[\leq -3,151]$	−0.0288***	0.0045	4.5459***
	(0.0060)	(0.0093)	(0.4850)
RealizedOutcomeQ$_{2[-2,790, -788]}$ / $[-3,150, -1050]$	−0.0255***	−0.0128*	3.5477***
	(0.0048)	(0.0075)	(0.3834)
RealizedOutcomeQ$_{3[-787, -63]}$ / $[-1,049, -250]$	−0.0138***	−0.0279***	1.7672***
	(0.0041)	(0.0069)	(0.3304)
RealizedOutcomeQ$_{4[-62, 0]}$ / $[-249, 40]$	Baseline	Baseline	Baseline
RealizedOutcomeQ$_{5[\geq 1]}$ / $[\geq 41]$	−0.0055	−0.0032	−0.5390
	(0.0042)	(0.0072)	(0.3401)
LogCumulativeNumberMinutes	−0.0638***		
	(0.0025)		
VisitNumber	0.0001	0.0060***	0.2790***
	(0.0003)	(0.0006)	(0.0356)
Slot machine dummies	X		
Session dummies	X	X	X
Date dummies	X	X	X
Player fixed effects	X	X	X
Number of casino customers	4,322	3,972	2,676
Observations	158,586	22,540	20,117
Within R^2	0.066	0.109	0.083

Notes: The heteroscedasticity-robust standard errors are given in parentheses. The first value range of *RealizedOutcomeQ*$_z$ refers to Column (1), whereas the second value range refers to Columns (2) and (3), respectively. In all models, *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

no notable effect of prior realized gains on risk-taking. The estimated coefficients for *LogT-winCasino* using 10 quantiles are shown in Column (2) of Table A1. Again, the results remain very similar.[16]

5.3.2. Unobserved realized outcomes before the first visit

Our main analysis rests on the assumption that casino customers have no prior realized gains or losses before their first visit in our dataset. This assumption is unlikely to hold for all casino customers because our data period starts at an arbitrary point in time. As a first modification, we omit the first visit of all casino customers and employ the total amount won or lost in the first visit as initial prior realized outcomes for subsequent visits. The results are displayed in Table A2 in the Appendix. Although the realized outcome values within the quintiles change, the interpretation of the results remains very similar.

To address the concern of unobserved realized outcomes before the first visit more rigorously, we investigate a subsample of casino customers who are less likely to exhibit prior realized losses from earlier casino visits. Based on further information from our Swiss casino, we know that 2,231 of the 4,322 individuals in our dataset did not visit the casino between October 1, 2015, and April 17, 2016, before our observation period. While this approach does not perfectly filter out all casino customers with prior realized outcomes from gambling at this casino, it allows us to remove the regular customers who did experience prior losses or gains in earlier visits.

Table 3 shows the result for this subsample of casino customers for the *LogTotalWager* in Column (1) and the *LogT-winCasino* in Column (2). For paper outcomes, the values within the quintiles barely change and the results remain very similar. For realized losses, the negative effect is less pronounced compared to the full sample. While the coefficients are directionally consistent for larger realized losses, only the coefficient of the quintile containing the largest losses in Column (1) is statistically significant. For realized gains, both Columns (1) and (2) consistently show no significant impact on risk-taking. Based on these findings, we conclude that the risk-taking pattern for the subsample of non-regular casino customers is similar to that of the full sample but that the negative effect after realized losses is weaker.

5.3.3. Additional risk measures

In our main analyses, we employ the total wager and the theoretical win for the casino per session as proxies for risk-taking. In addition, the casino setting allows us to investigate several further risk measures. Within a visit, a casino customer decides whether to continue gambling at another slot machine or to leave the casino. Presuming that leaving the casino is the less risky option than staying in the casino, we investigate how the likelihood of playing another session depends on prior paper and realized outcomes. Column (1) of Table 4 displays the regression results for the decision to play another session.

Regarding paper outcomes within a visit, the results show that prior gains increase the probability of playing another session, while prior losses decrease the probability of playing another session. While the latter result seems inconsistent with previous findings, the decision to play another session after paper losses might not be a primary risk choice. Every individual must leave the casino eventually, and due to the nature of casinos, it seems likely that most of these individuals leave the casino with losses. Thus, although we control for the cumulative time spent in the casino, paper losses seem systematically related to the decision to leave the casino independent of risk considerations. This issue is less relevant for paper gains, for which the decision to play another session might be a more accurate risk measure. Consistent with previous findings, the results for realized outcomes from earlier visits show that prior losses decrease the probability of playing another session, while prior gains have no effect.

Across visits, we employ the decision to visit the casino again and the number of days between visits as proxies for risk-taking. Presuming that visiting the casino again involves more risk than any other activity, we estimate how this decision is influenced by realized outcomes from earlier casino visits.[17] Column (2) of Table 4 displays the results for this analysis. Compared to the baseline, prior realized losses in Q_3 and Q_2 significantly reduce the likelihood of visiting the casino again. However, the largest prior realized losses in Q_1 have no effect on the decision to visit the casino again. Thus, these findings are broadly consistent with less risk-taking after realized losses, but the size of the prior realized loss does not seem to amplify this relationship. For realized prior gains, we consistently find no effect on the propensity to visit the casino again.

Finally, given that a customer has decided to visit the casino again, we can employ the number of days between visits as a further measure

[16] Furthermore, because the distribution of prior outcomes is skewed, one might be concerned that our results are driven by a few observations. Although outliers might affect only the most extreme quantiles in our estimations, winsorizing both prior outcomes within and across visits at the 1st and 99th percentiles does not change our results.

[17] Because we do not observe whether a casino customer visits the casino again after our data period, we exclude the decision to visit the casino again after the last visit if the last visit is within the last 3 weeks of our observation period. The results are very similar if we omit the last visit within the last 2 or 4 weeks in our dataset. This leaves 22,540 decisions from originally 24,439 visits.

that captures risk-taking after realized outcomes in a different way. Consequently, the smaller the number of days between visits, the more risk a casino customer is willing to take. Column (3) of Table 4 displays the results for the time delay between visits. Relative to the baseline, prior losses have a positive effect on the number of days between visits. Furthermore, as the size of the prior realized losses increases, the estimated coefficients become more pronounced. This finding is in line with our hypotheses that prior realized losses decrease risk-taking and that larger prior realized losses amplify this relationship. As expected, prior realized gains do not significantly affect the number of days between two visits and thus do not alter risk-taking behavior.

6. Discussion and conclusion

We examine the realization effect in the field using individual gambling data from a Swiss casino. This unique setting allows us to clearly differentiate between paper losses and gains occurring during a casino customer's visit and realized losses and gains across a casino customer's visits. We find evidence that casino customers increase their risk-taking after both paper losses and paper gains within a visit and that this effect is more pronounced for larger outcomes. In contrast, our results for realized outcomes show that losses reduce subsequent risk-taking if losses are comparatively large, whereas realized gains do not affect subsequent risk-taking. These findings remain broadly unchanged in a variety of robustness checks. Overall, our results provide strong empirical support for the predictions of the realization effect for both prior losses and prior gains.

Additionally, our paper sheds light on whether loss aversion depends on prior realized outcomes. Our results suggest that a greater distaste for future losses is triggered only if prior realized losses are comparatively large. In particular, only cumulative prior realized losses of approximately CHF 800 or above, which is eight times more than the median final balance of CHF -100 for a single visit, significantly decrease risk-taking. However, further research on how individuals respond to different sizes of prior realized losses in various other contexts is needed.

Although our casino setting offers many advantages, several limitations remain. First, we cannot completely rule out wealth effects as an explanation for lower risk-taking after large realized losses across visits. Indeed, large realized losses from previous visits might impact discretionary spending income and force people to spend less during subsequent visits. However, the losses of casino customers seem rather small compared to their lifetime wealth. Moreover, the total gains and losses in Smith et al. (2009) and Eil and Lien (2014), who study risk-taking using online poker, are considerably larger. For example, half of the poker players investigated in Smith et al. (2009) won or lost more than \$200,000, and 10% won or lost more than \$1 million. Second, there might be a selection effect whereby more risk-seeking individuals decide to visit the casino again. However, because our setting allows a clean identification of risk-taking within a visit and all of our models include individual fixed effects, this type of selection may not be a major confounding factor. Moreover, a selection of more risk-seeking individuals would work against our findings of realized outcomes and, in the worst case, lead us to underestimate the realization effect. Finally, our data period starts at an arbitrary point in time, and realized outcomes from visits before our observation period remain unobservable. While this data limitation remains, our subsample analysis of non-regular casino customers indicates that our main findings are not substantially influenced by unobserved prior outcomes from earlier visits.

In the following, we discuss explanations for discrepancies in the results from previous papers that use field data from gambling environments. Both Smith et al. (2009) and Eil and Lien (2014) investigate data from online poker players. While Smith et al. (2009) investigate risk-taking just after large wins or losses, Eil and Lien (2014) focus on risk-taking after prior outcomes within a poker-playing session.[18] Thus, prior outcomes are likely to remain paper outcomes in both studies. Consistent with our results, Smith et al. (2009) and Eil and Lien (2014) find that prior losses increase risk-taking. However, neither study finds evidence for a house money effect after gains. Eil and Lien (2014) explain this result with a reference-dependent labor supply. Specifically, the poker players in their sample are successful players who earn approximately 40 dollars per hour on average. Thus, these players might tend to stop playing in response to being ahead because they value leisure more than further gains. For slot machine players, such labor supply considerations should not matter because players lose money on average.

Furthermore, Suhonen and Saastamoinen (2017) find that online horse race bettors take less risk after (paper) losses but simultaneously exhibit a break-even effect. While this is feasible in horse race betting because odds and stakes can be freely combined, risk-taking within a session at a particular slot machine can be achieved only through higher

Table A1
Main results for 10 prior outcome quantiles.

	LogTotalWager (1)	*LogT-winCasino* (2)
Prior outcomes within the visit		
PaperOutcomeQ$_{1[\leq -598]}$	0.1504***	0.1468***
	(0.0271)	(0.0278)
PaperOutcomeQ$_{2[-597,\ -310]}$	0.1117***	0.1160***
	(0.0222)	(0.0227)
PaperOutcomeQ$_{3[-309,\ -180]}$	0.0795***	0.0812***
	(0.0199)	(0.0218)
PaperOutcomeQ$_{4[-179,\ -97]}$	0.0738***	0.0756***
	(0.0178)	(0.0182)
PaperOutcomeQ$_{5[-96,\ -38]}$	0.0346**	0.0374**
	(0.0162)	(0.0162)
PaperOutcomeQ$_{6[-37,\ 0]}$	Baseline	Baseline
PaperOutcomeQ$_{8[1,\ 80]}$	0.0594***	0.0569***
	(0.0179)	(0.0182)
PaperOutcomeQ$_{9[81,\ 365]}$	0.0692***	0.0714***
	(0.0203)	(0.0205)
PaperOutcomeQ$_{10[\geq 366]}$	0.1848***	0.1917***
	(0.0235)	(0.0240)
Prior outcomes between visits		
RealizedOutcomeQ$_{1[\leq -5,509]}$	−0.1647***	−0.1699***
	(0.0398)	(0.0407)
RealizedOutcomeQ$_{2[-5,508,\ -2,791]}$	−0.0926***	−0.0914***
	(0.0310)	(0.0321)
RealizedOutcomeQ$_{3[-2,790,\ -1,519]}$	−0.0566**	−0.0557**
	(0.0276)	(0.0281)
RealizedOutcomeQ$_{4[-1,518,\ -788]}$	−0.0599**	−0.0625**
	(0.0271)	(0.0282)
RealizedOutcomeQ$_{5[-787,\ -324]}$	−0.0225	−0.0272
	(0.0227)	(0.0231)
RealizedOutcomeQ$_{6[-323,\ -63]}$	−0.0004	0.0014
	(0.0220)	(0.0219)
RealizedOutcomeQ$_{7[-62,\ 0]}$	Baseline	Baseline
RealizedOutcomeQ$_{9[1,\ 394]}$	0.0035	0.0091
	(0.0222)	(0.0223)
PaperOutcomeQ$_{10[\geq 395]}$	0.0271	0.0327
	(0.0258)	(0.0264)
VisitNumber	0.0016	0.0013
	(0.0013)	(0.0014)
Slot machine dummies	X	
Session dummies	X	X
Date dummies	X	X
Player fixed effects	X	X
Within R^2	0.048	0.005

Notes: The heteroscedasticity-robust standard errors are given in parentheses. The number of casino customers is 4,322, and the number of observations is 158,586. *PaperOutcomeQ*$_7$ and *RealizedOutcomeQ*$_8$ are missing because the baseline quantiles contain many zeros that cannot be split up between quantiles. In all models, *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

[18] Eil and Lien (2014) assume that a poker playing session ends when a player does not play any poker for at least six hours.

Table A2
Main results without the first visit.

	LogTotalWager (1)	*LogT-winCasino* (2)
Prior outcomes within the visit		
$PaperOutcomeQ_{1[\leq -310]}$	0.1063***	0.1066***
	(0.0195)	(0.0200)
$PaperOutcomeQ_{2[-309, -97]}$	0.0554***	0.0559***
	(0.0134)	(0.0147)
$PaperOutcomeQ_{3[-96, 0]}$	Baseline	Baseline
$PaperOutcomeQ_{4[1, 80]}$	0.0375**	0.0370**
	(0.0166)	(0.0168)
$PaperOutcomeQ_{5[\geq 81]}$	0.1016***	0.1061***
	(0.0176)	(0.0179)
Prior outcomes between visits		
$RealizedOutcomeQ_{1[\leq -3,434]}$	−0.1090***	−0.1144***
	(0.0336)	(0.0345)
$RealizedOutcomeQ_{2[-3,433, -1,259]}$	−0.0613**	−0.0612**
	(0.0241)	(0.0250)
$RealizedOutcomeQ_{3[-1,258, -350]}$	−0.0432**	−0.0486**
	(0.0216)	(0.0229)
$RealizedOutcomeQ_{4[-349, 46]}$	Baseline	Baseline
$RealizedOutcomeQ_{5[\geq 47]}$	0.0115	0.0140
	(0.0208)	(0.0214)
VisitNumber	0.0016	0.0014
	(0.0014)	(0.0015)
Slot machine dummies	X	
Session dummies	X	X
Date dummies	X	X
Player fixed effects	X	X
Observations	136,738	136,738
Within R^2	0.049	0.005

Notes: The heteroscedasticity-robust standard errors are given in parentheses. The number of casino customers is 2,676. In all models, *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

total wagers. Finally, also using slot machine data, Flepp and Rüdisser (2019) find that risk-taking is lower after players hit a jackpot than before they hit a jackpot. However, due to the negative expected value of slot machines, gambling before hitting a jackpot is likely to be shaped by losses. Thus, instead, this type of analysis compares risk-taking after gains to risk-taking after losses, which is different from comparing risk-taking after gains to risk-taking at the reference point.

Our results have important implications for casino operators. Casinos typically aim to encourage their customers to stay longer and gamble more (Ho et al., 2019). While this behavior likely translates into higher revenues for casinos due to the increased risk-taking of gamblers during their visit, it might be detrimental in the long run because gamblers will be more cautious in their subsequent visits if their prior losses are comparatively large. Thus, casino operators could more actively manage this trade-off by preventing customers from accumulating large losses within a visit.

Our findings also have important policy implications for “responsible gambling” initiatives. As Zhang and Clark (2020) note, the realization of losses could depend on the detailed features of the game environment. For example, the design of the card system might be crucial. Whereas customers redeem and dispose of their card when leaving the casino in our study, other casinos offer customer loyalty cards where funds can be stored. While our results suggest that the former design encourages the realization of losses, the latter design may promote the perception that losses remain on paper, which could further enhance the problem of loss-chasing.

More generally, our results also have significant managerial implications. Given that the size of both paper losses and gains further increases the propensity to take risks, it is crucial that any paper outcomes be recognized immediately and be realized if needed. For example, paper outcomes from investment decisions could be automatically reported to the overseeing department to close the mental accounts of employees.

CRediT authorship contribution statement

Raphael Flepp: Conceptualization, Methodology, Formal analysis, Writing - review & editing. **Philippe Meier:** Conceptualization, Methodology, Formal analysis, Writing - original draft. **Egon Franck:** Conceptualization, Writing - review & editing, Supervision.

Appendix

See Tables A1 and A2.

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